nearly but not quite homogeneous, would alter altogether the appearance of a fracture.

In this note only isotropic materials are considered, but it seems probable that the same principles might be used to explain the cleavage of crystals.

The Rotation of the Electric Arc in a Radial Magnetic Field.

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The following paper contains an account of a series of measurements of the velocity of motion of an electric arc in a magnetic field at right angles to its length. The experiments are similar to those made by Prof. Wilson and Mr. G. H. Martyn* with the electric discharge in a vacuum tube and were suggested by Prof. Wilson.

The apparatus consisted of a vertical iron rod (fig. 1, A) magnetised by two solenoids B at its ends, wound in opposite directions, so as to give a pole in the middle of the bar. With this arrangement the field round the middle of the bar is uniform and radial. The distance between the two solenoids was fixed by a quartz tube C, which also served to protect the iron rod from the heat of the arc.

The arc passed between two copper tubes D, 2 cm. in diameter, held coaxial with the iron rod by a clamp made of wood and brass. The copper tubes were clamped in holes cut in two pieces of thick (5 mm.) sheet brass E, fixed to the top and bottom of a block of hard wood F. The required arc length was obtained by clamping the electrodes while they were pressed firmly against a gauge of sheet brass held between them.

The base of the iron rod and the stand carrying the arc electrodes each rested on three screws in a hole slot and plane fixed to the table by paraffin wax. Thus the whole apparatus could be quickly taken down and set up again in the same position. This was necessary to enable the electrodes to be renewed after each experiment.

The arc was in all cases started with the magnetic field already in action, by momentarily bringing a piece of arc-lighting carbon in contact with the two electrodes.

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* 'Roy. Soc. Proc.,' A, vol. 79, 1907.

Experiments were first made with carbon electrodes, but though the discharge could be started and would occasionally make a few revolutions it never lasted for more than one or two seconds. An iron-iron and an iron-mercury arc were tried with equally unsatisfactory results. Then a copper arc was used and with it all the experiments described in this paper were made.

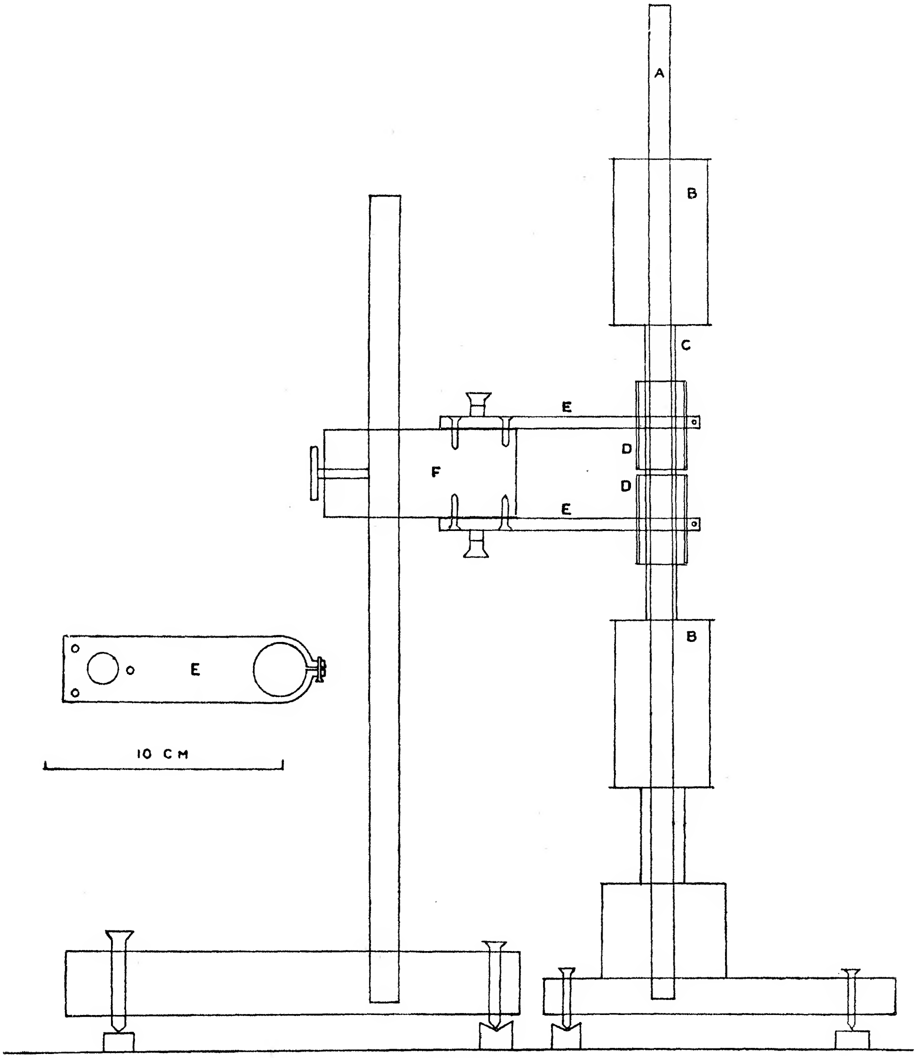

Fig. 1.

The current for the arc was taken from the electric lighting supply at 200 volts and as the arc used only about 50 volts a large amount of resistance had to be put in the circuit. A few experiments were done with the 100-volt supply, but the arc was then much more liable to go out before the necessary reading had been obtained; it was therefore preferred to use the 200-volt supply. The current used was measured by means of an Elliott portable standard ammeter reading up to 15 amperes.

Though the copper arc was much more stable than any of the others which had been tried, the discharge seldom lasted for longer than thirty seconds, and then only when brightly polished electrodes were used. After every second or third discharge therefore, the apparatus was taken down and the electrodes replaced by fresh ones while the old ones were repolished in a lathe with fine emery paper.

As the discharge only lasted for so short a period, a stroboscopic method of measuring the speed of rotation was out of the question, and in place of it a photographic one involving the use of a rotating mirror was employed. The mirror was fixed not quite normally on one end of the shaft of a small electric motor. When the motor was working, a point source viewed in the mirror appeared drawn out into a circle of light, and if the point source was intermittent this circle was broken into as many dots as the number of times the source became active during each revolution of the motor. The intermittent source was obtained by placing a vertical slit in front of the arc. This was illuminated by the arc once every time it revolved round the iron bar. The image of the slit in the rotating mirror was then photographed with an ordinary camera. The shutter was adjusted so that the plate was exposed for a little longer than the time taken by the mirror to make one revolution. By this means a slight overlapping of the dots at the beginning and end of the exposure was insured and it was consequently easy to count to the nearest tenth the number of revolutions made by the arc during one revolution of the mirror.

Imperial Special Rapid plates were used and gave satisfactory results; isochromatic (Imperial N.F.) plates were tried but did not give nearly so dense an image. Three exposures were taken on each plate, the rising front of the camera being moved between each pair of exposures. To count the number of dots the negatives were copied on tracing paper, as the counting was more easily done on these tracings than on the original negatives.

To turn the mirror an $\frac{1}{8}$-H.P. series motor designed for 100 volts was employed. It was used, however, as a separately excited machine, the field magnet circuit being connected to the 100-volt mains through an 8-C.P. lamp, and the armature windings supplied with current from an 8-volt accumulator. The speed was regulated by an adjustable resistance in the armature circuit. The number of revolutions made by the motor was registered by a Veeder revolution counter (fig. 2, E) fixed to the opposite end of the shaft from the mirror. To determine the speed, the time of 100 revolutions was taken with a stop-watch.

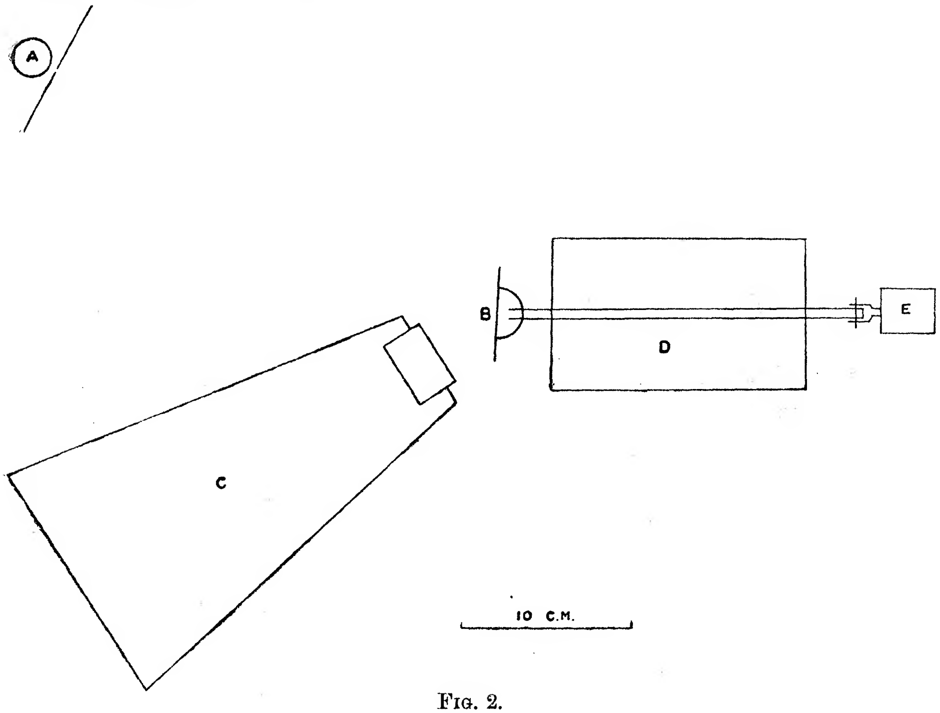

Fig. 2.

The motor was run at about 250 revolutions a minute, and the camera exposure was about $\frac{1}{3}$ of a second (a nominal second with a Unicum shutter).

The relative positions of the arc A, motor D with mirror B, and the camera C, are shown in fig. 2.

Theory of the Rotation of the Arc.

If k_1 and k_2 are the velocities of the ions due to unit electric force, the rate at which the arc moves is given by the expression*

$$v = \mathrm{HX}k_1k_2, \quad \text{or} \quad k_1k_2 = \frac{2\pi n}{\mathrm{H}/r\,.\,\mathrm{X}},$$

if n is the number of revolutions the arc makes per second, and H and X the magnetic and electric forces, and r the radius of the electrode.

The following is a proof of this relation. The velocity of drift of an ion along the arc is Xk. This motion of the ion in a magnetic field causes a transverse electric force H . Xk to act on the ion which gives it a transverse velocity HXk^2. Hence the transverse displacement of an ion while it passes from one electrode to the other is $HXk^2 . l/Xk = Hkl$ where l is the arc length.

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* Wilson and Martin, *loc. cit.*

Although, unless the velocities of the two ions are the same, the arc will not remain parallel to the axis during rotation, the two ends will eventually move at the same speed and their position will be given by

$$y_1 = vt \text{ for anode end,} \qquad y_2 = a+vt \text{ for cathode end.}$$

A positive ion starting from the anode and moving to the cathode in a time l/Xk_1 must then travel a distance $a + v\,l/Xk_1$ transversely.

Similarly, the transverse motion of a negative ion is $-a+v\,l/Xk_2$.

Equating these to the values previously found, we get

$$a+v\,l/Xk_1 = Hk_1l, \qquad -a+v\,l/Xk_2 = Hk_2l:$$

thus

$$v = HXk_1k_2.$$

Eliminating v instead of a from the above two equations, we get

$$a/l = H(k_1-k_2).$$

The maximum value of H used was 150, and k the velocity of the ions in unit (C.G.S. electromagnetic) field is not greater than 5×10^{-6}, so that a/l, which measures the inclination of the arc to the axis, is always very small. This explains the observation made by Wilson and Martin that the discharge in their experiments always remained perpendicular to the electrodes during its motion.

Measurement of the Magnetic Field H.

The magnetising current was supplied from an 8-volt accumulator, and was measured by means of an ammeter similar to the one used for the measurement of the arc current, but reading only to 5 amperes. The ammeters are issued as correct to 1/5 per cent., and they were found to agree with one another perfectly. A reversing key was included in the magnetising circuit, and the current was frequently reversed when any change was made in the magnetisation. In going from a higher to a lower magnetisation, the iron was first demagnetised by the method of reversals, in order to insure that the field should be a definite function of the magnetising current and independent of the permanent magnetism retained by the bar.

The actual values of the field (or rather of H/r, which is constant for a radial field) for different magnetising currents, were found as follows, the method being the same as that used by Wilson and Martin.

Two coils of 50 turns each were wound in grooves turned on a boxwood cylinder of the same diameter as the copper tubes used as electrodes for the arc discharge. The two coils were first connected in opposition and placed in the position usually occupied by the arc. The coils were connected to a low resistance Broca ballistic galvanometer, and the deflections produced by reversing various currents in the magnetising solenoids of the iron bar observed. The connections of the coils were then so altered that they were in series, and that a current would pass round them in the same direction. The coils were removed from the iron bar and placed along the axis of a long solenoid at its centre, and the deflection produced by reversing the current in the solenoid observed.

Let n be the number of turns in each coil on the boxwood cylinder,
r radius of mean area of section of these coils,
l their separation,
N number of turns on long solenoid.
2L and R its length and radius.
i_0 the current in amperes reversed in it.
δ and δ_0 the galvanometer swings produced by reversing the field due to the iron bar and to the long solenoid respectively ; then

$$\frac{\delta}{\delta_0} = \frac{\mathrm{H}2\pi r l n}{2n\pi r^2 \frac{4\pi\mathrm{N}}{2\mathrm{L}}\left(1-\frac{\mathrm{R}^2}{\mathrm{L}^2}\right)\frac{i_0}{10}}, \qquad \frac{\mathrm{H}}{r} = \delta\,\frac{i_0}{10\delta_0}\,\frac{4\pi\mathrm{N}}{2\mathrm{L}}\left(1-\frac{\mathrm{R}^2}{\mathrm{L}^2}\right)\frac{1}{l}.$$

Substituting the values used,

$$\frac{\mathrm{H}}{r} = \frac{4{\cdot}75}{10\times 9{\cdot}8}\,\frac{4\pi 200}{26{\cdot}4}\,0{\cdot}974\,\frac{1}{1{\cdot}07} = 4{\cdot}20\delta.$$

The values of δ were plotted on squared paper against the values of the magnetising current in amperes i_{H}, and were found to lie on a straight line. Substituting the value thus found, we get

$$\mathrm{H}/r = 4{\cdot}20\times 8{\cdot}3\,(i_{\mathrm{H}}-0{\cdot}1) = 34{\cdot}9\,(i_{\mathrm{H}}-0{\cdot}1).$$

As H/r occurs in the expression for the ionic velocities, it is obvious from the above deduction that it is not necessary to know either the diameter of the coils on the boxwood cylinder, or the number of turns in them. The diameter of the coils was, however, made equal to the diameter of the arc electrodes, to avoid any error which would result from the field not being radial. The separation of the coils was four or five times the length of arc usually employed, but this does not introduce an error, inasmuch as experiment showed that the field varied very little along the iron bar, the variation being under 1 per cent. per centimetre. The equality of the number of turns in the two coils was tested by placing them, together with an iron core, inside the long solenoid while they were connected in opposition. The deflection obtained on reversing the current in the solenoid was negligible compared with that obtained when a single turn of wire round the core was substituted for the two coils in opposition.

All the connections of the coils were soldered so that the total resistance in the circuit, about 2 ohms, should be the same in both experiments.

Measurement of the Electric Force X.

In order to obtain a value of the electric force in the arc, it was assumed that the change in the P.D. observed when the length of the arc was altered at constant current was equal to the product of the electric force and the change in length. This is equivalent to assuming that the potential-drops at the two electrodes are independent of the length of the arc. Probably this is not quite true, as lengthening the arc may affect the temperature of the electrodes. In any case the method is only a rough one, as the change in the P.D. used is only the difference between two much larger observed P.D.'s. No better method of measuring the field, however, suggested itself.

The value of the arc P.D. was measured for various currents for arc lengths of 0·272 and 0·360 cm. by means of an Elliott portable standard voltmeter reading to 120 volts. When the arc was not running, the P.D. between the electrodes was 200 volts. To protect the voltmeter from this high voltage, an automatic switch, actuated by an electromagnet in the main arc-circuit, was used.

Very rough experiments showed that the rotation of the arc had a considerable effect on its P.D., which was about 10 volts higher when the arc was stationary than when it was moving. At first it seemed that the speed of rotation had an effect on the P.D., but more careful experiments showed that this was not the case. The spurious effect at first noticed was caused by using the electrodes for a second discharge without cleaning them. In order to obtain consistent readings, it was found to be essential before each experiment to repolish the electrodes in a lathe. If the arc was started again after it had gone out, it was found that the P.D. had gone up by 3 to 4 volts. In most cases the P.D. remained quite steady during the first discharge, however long this lasted, but rose several volts as soon as the discharge was stopped and restarted. With currents of about 5 amperes a curious phenomenon was noticed. Soon after starting the discharge, the P.D. would rise steadily 4 or 5 volts and then fall again to its original value, remaining steady until the arc went out. This did not happen with larger or smaller values of the current.

The values of the P.D. obtained were multiplied by the arc current and the resulting product plotted against the current, as was done by Mrs. Ayrton in the case of the carbon arc. The curves obtained were not quite straight lines as they were in Mrs. Ayrton's experiments, but were very nearly so. Corresponding ordinates of the smooth curves were subtracted, and the differences $\delta(\mathrm{V}i)$ plotted against i. The points thus obtained lay with sufficient accuracy on a straight line giving

$$\delta(\mathrm{V}i) = 3{\cdot}75+5i, \qquad \mathrm{X} = \frac{1}{0{\cdot}088}\left(5+\frac{3{\cdot}75}{i}\right) = 57+\frac{42{\cdot}5}{i}.$$

The observations on which this formula is based are given in Tables I, II, III. Table I shows how V depends on the rotation of the field and the newness of the electrodes. Table II contains the experiments with an arc length of 0·272 cm.; Table III those with an arc length of 0·360.

Table I.

a.	i_{H}.	i.	V.
1	2·8	7·9	42·5
1	2·0	7·9	42
*1	1·0	7·9	42
*2	2·8	—	45·5
*4	2·8	—	48
*7	0·0	9·5	31
1	2·5	4·3	48·5
1	1·0	4·5	48·5

"a" is the number of the experiment after insertion of new electrodes.

* These experiments were done with the same electrodes and the same resistance in circuit.

Table II.

i.	V.	Vi.
1·45	64·0	93
3·0	53·5	160·5
4·4	48·5	213
5·2	46·75	243
5·4	46·8	252
6·6	43·7	288
7·9	42·2	333
8·45	40·0	338
9·3	40·2	374
11·6	37·5	435
13·0	37·0	481
15·1	35·0	528

Table III.

i.	V.	Vi.
1·65	69·0	104
2·03	64·75	131·5
2·95	60·5	178
3·35	57·75	193
4·73	53·75	254
5·13	52·5	269
6·7	48·5	325
7·8	47·0	367
8·4	46·5	390
9·75	44·4	432
11·47	43·0	492
11·7	43·0	503
13·4	42·0	563
14·2	40·75	577

The particulars of the experiments on the speed of rotation of the arc are collected in Tables IV—VII. It was found that there was a considerable falling off in the speed of rotation if the same electrodes were used a second time without cleaning; this was especially noticeable when the arc length was short (under 2 mm.). On this account only those experiments which were made with freshly polished electrodes have been tabulated, and all such experiments are included in the tables. (Two second experiments are included, but a special allowance is made for them.)

Table IV.—Arc Length 0·185 cm.

No.	i_H.	i.	Dots.	Time, 100 motor revs.	Arc revs. per sec.	Reduced values.		Means.
					$i_H - 0·1$.	i.	$n/(i - 0·1)$.	
11t	3·02	1·80	13·0	26·5	16·8	2	17·9	18·15
6t	2·95	2·10	15·0	27·8	18·95	2	18·4	
B2m	3·61	4·31	27·1	23·6	32·4	4·3	32·3	30·6
9b	2·90	4·30	23·8	26·6	31·9	4·3	31·9	
8m	2·95	4·29	22·6	26·6	29·9	4·3	29·9	
9t	2·93	4·27	21·4	25·8	29·3	4·3	29·5	
10t	2·94	4·27	22·7	26·6	30·0	4·3	30·2	
B1b	2·50	4·27	17·8	25·2	29·4	4·3	29·6	
D6m	2·10	4·45	13·9	21·3	32·6	4·3	32·0	
D6b	2·11	4·43	15·0	21·9	34·1	4·3	33·7	
12t	2·04	4·20	12·2	23·5	26·8	4·3	27·3	
B1t	1·48	4·30	6·4	25·3	18·3	4·3	18·3	omitted
Mean of 8 2nd experiments...........						4·3	—	26·6
„ 1 2nd experiment						6·1	—	33·8 corr. 38·9

Table V.—Arc Length 0·230 cm.

4Ct	2·50	2·00	12·2	21·9	23·2	2	23·2	22·8
1t	2·03	1·95	10·2	26·9	19·6	2	19·8	
4Cb	1·53	2·00	8·3	22·9	25·3	2	25·3	
9Bt	4·11	4·15	25·8	22·8	29·0	4	28·4	30·9
3Bt	2·96	4·12	22·5	23·8	33·0	4	32·5	
5Bt	2·52	4·04	19·1	24·6	32·1	4	31·9	
11Bm	3·99	6·10	34·0	23·2	37·7	6	37·3	38·1
3Cm	3·48	5·98	23·7	22·6	38·2	6	38·3	
3Bb	2·99	6·10	29·2	24·3	38·0	6	37·6	
3Ct	2·49	6·03	22·6	23·3	40·6	6	40·5	
3t	2·05	5·83	16·3	26·9	31·1	6	31·8	
1Ct	2·07	6·21	17·7	22·2	40·5	6	39·7	
12Bm	1·48	6·03	13·9	22·6	44·9	6	44·8	
2Ct	0·98	6·06	7·1	23·1	34·9	6	34·7	
9Bb	3·28	9·15	40·8	24·2	53·5	9	52·9	51·3
4Bm	2·97	8·72	38·1	25·1	53·2	9	54·3	
10Bt	2·51	9·28	30·2	22·4	56·0	9	54·9	
10Bm	2·05	9·11	22·8	22·9	50·8	9	50·4	
10Bb	1·49	9·07	15·8	22·7	50·1	9	49·8	
11Bt	1·04	9·03	7·5	22·1	45·8	9	45·7	

Table VI.—Arc Length 0·272.

No.	i_H.	i.	Dots.	Time, 100 motor revs.	Arc revs. per sec.	Reduced values.		Means.
					−0·1.	i.	$n/(i_H-0·1)$.	
D3m	2·08	1·83	9·9	22·3	22·4	2	23·1	23·1
D2t	3·10	4·00	21·9	22·9	31·9	4	31·9	32·1
0t	2·50	4·08	17·3	23·5	30·7	4	30·4	
B6m	2·05	4·03	14·4	24·5	30·1	4	30·0	
D1t	2·11	3·98	14·9	22·6	32·8	4	32·9	
D2b	1·15	4·22	9·0	23·7	36·2	4	35·3	
D4t	3·06	5·80	24·2	21·5	38·0	6	38·8	39·3
D5b	2·12	6·05	17·4	21·5	40·1	6	39·9	
D5t	1·12	5·87	8·7	22·0	38·8	6	39·3	
B7m	2·03	8·71	23·25	24·4	49·4	8·5	48·6	48·6
Means of all readings—5 1st............ 5 2nd............ 3 3rd............						4	—	30·9
3 1st............ 3 2nd............						6	—	38·6

Table VII.—Arc Length, 0·360.

B8t	2·05	3·97	13·8	23·7	29·8	4	29·9	29·9
B8m	2·04	5·70	16·4	24·2	34·9	5·7	34·9	36·2
B8b	2·03	3·80	12·8	24·4	27·2	4	27·8	

NOTE.—These are 1st, 2nd and 3rd experiments, and 2nd has been corrected to 1st by supposing falling-off takes place uniformly.

Most of the experiments were made with arc lengths of 0·230 or 0·272 cm. Arc lengths of 0·185 and 0·360 cm. were also used. As far as the accuracy of the experiments extends, the arc length appears to have no influence on the speed of rotation.

It was provisionally assumed that the speed of rotation was proportional to the magnetic field, and consequently to $i_H-0·1$ (see determination of magnetic field). The numbers obtained by dividing the number of rotations per second by $i_H-0·1$ were therefore plotted against the current. Before this was done the experiments were averaged in the following manner:—As far as possible the current in each experiment was made a whole number of amperes, but to do this exactly was not possible, since there was no time to make any adjustments after the arc had been started, the greater part of the time it lasted being necessary to read the ammeter and take a photograph. The speed of rotation was found to increase with the current approximately linearly, and a rough value of the rate of increase was used to reduce each observation of $n/(i \ -0{\cdot}1)$ to the value corresponding to the nearest whole number of amperes. Means of the readings for each current were then taken and plotted against the current.

The values of $n/(i_{\mathrm{H}}-0{\cdot}1)$ obtained for the same current in different experiments showed very considerable variations (10 to 20 per cent. in extreme cases), but these variations were irregular, and there was no evidence to show that $n/(i_{\mathrm{H}}-0{\cdot}1)$ depended on the magnitude of $i \ -0{\cdot}1$, as it would do were the speed of rotation not proportional to the strength of the magnetic field.

The final results reduced in the above way are collected in the following table corresponding to fig. 3—

i ……………	$n/(i_{\mathrm{H}}-0{\cdot}1)$.			
	$l = 0{\cdot}185$.	$0{\cdot}230$.	$0{\cdot}272$.	$0{\cdot}360$.
2 …………	18·15 (2)	22·8 (3)	23·1 (1)	
4 …………	—	30·9 (3)	32·1 (5)	29·9 (1)
4·3 …………	30·6 (10)			
6 …………	38·3* (1)	38·1 (8)	39·3 (3)	37·3* (1)
8·5 …………	—	—	48·6 (1)	
9 …………	—	51·3 (6)		

The numbers in brackets indicate the number of experiments used in getting the mean value.

* These numbers are obtained from experiments made with electrodes used a second time without cleaning.

The actual values of the field used varied from 35 to 140 C.G.S. units.

The speeds of rotation observed varied from 30 to 170 revs. per second corresponding to linear velocities of from 200 to 1100 cm. per second.

The values of $n/(i_{\mathrm{H}}-0{\cdot}1)$ in the above table have been plotted against the current in fig. 3, and it will be seen that the points lie approximately on the straight line

$$n/(i_{\mathrm{H}}-0{\cdot}1) = 4{\cdot}1\,i + 14{\cdot}2,$$

or substituting the values

$$\mathrm{H}/r = 34{\cdot}9\,(i_{\mathrm{H}}-0{\cdot}1), \quad \text{and} \quad 2\pi r n = v,$$

$$v = \mathrm{H}\,(2{\cdot}55 + 0{\cdot}74\,i).$$

Substituting the experimental numbers for $n, \mathrm{H}/r$, and X in the equation

$$k_1 k_2 = \frac{2\pi n}{\mathrm{H}/r\,.\,\mathrm{X}},$$

we obtain the following values of the product of the two ionic velocities per unit electric intensity for different values of the current. If k_1 and k_2

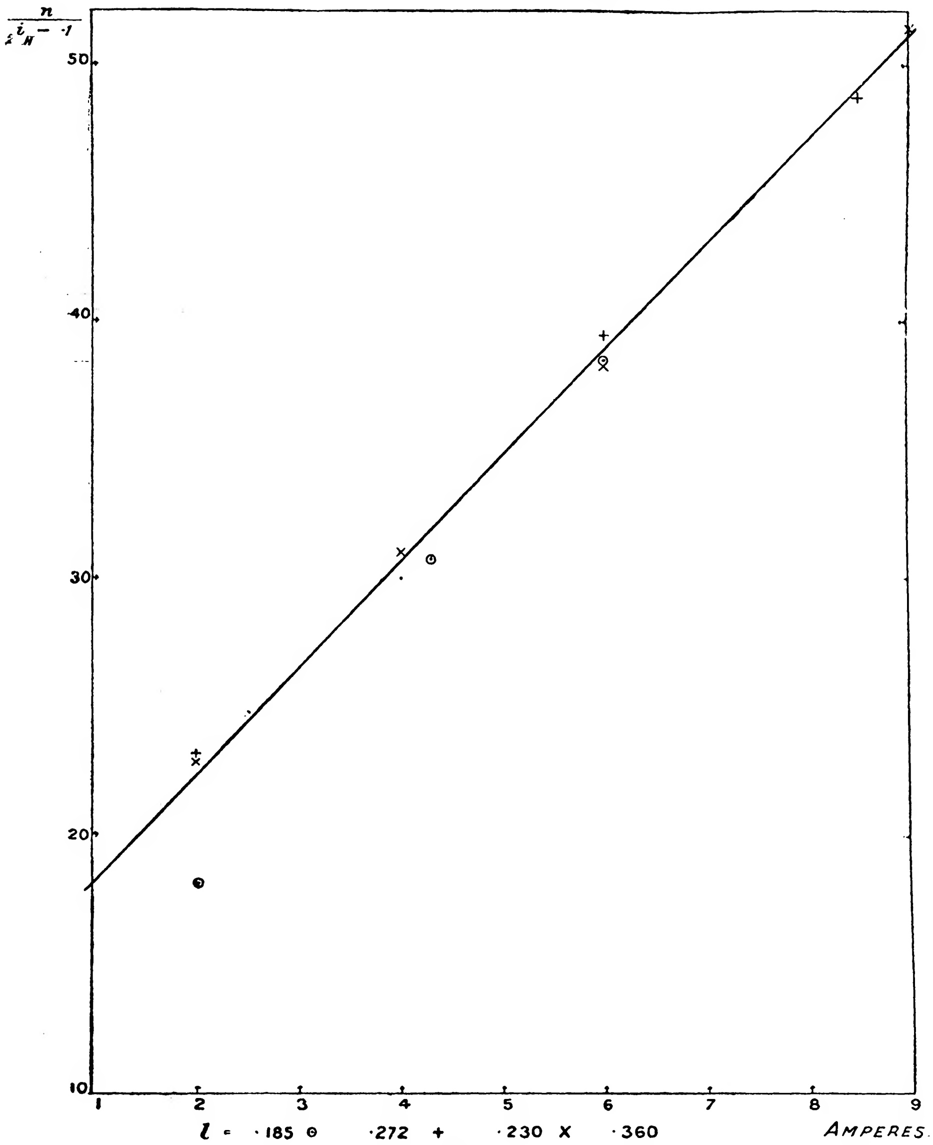

FIG. 3.

are the velocities per volt per centimetre, the numbers must be multiplied by 10^{16}.

i.	$n/(i_H - 0\cdot 1)$.	$H/r\ (i_H - 0\cdot 1)$.	$X \times 10^{-8}$.	$k_1 k_2 \times 10^9$.
2	23	34·9	78	0·53
4	31	34·9	67·5	0·83
6	38	34·9	64	1·07
9	51	34·9	62	1·5

Assuming that the negative ion in these experiments is a corpuscle, its velocity can be calculated from the expression—

$$k = e\lambda/mu.^*$$

Neglecting any effect its charge may have, the mean free path λ of a corpuscle in air should, owing to its small size, be four times that of an air molecule, a relation which agrees with experiment.† Taking the temperature of the arc to be 2000° C. and the mean free path of an air molecule at 0° C. as 10^{-5}, we get $\lambda = 10^{-5}\frac{2273}{273}\times 4$. To find u, the mean agitation velocity of the corpuscle, assume that the equation of $mu^2 = m_{\mathrm{H}}u_{\mathrm{H}}^2$ holds between the corpuscles and the gas particles; this gives $u = \sqrt{\frac{m_{\mathrm{H}}}{m}}185000\sqrt{\frac{2273}{273}}$, if we take 1850 metres a second as the velocity of a hydrogen molecule at 0° C.

Substituting in the expression for k, we get

$$k = 4\times 10^{-5}\sqrt{\frac{e}{m}}\sqrt{\frac{e}{m_{\mathrm{H}}}\frac{2273}{273}}\frac{1}{185000};$$

but $$e/m = 1{\cdot}9\times 10^{7},\ \text{and}\ \frac{e}{m_{\mathrm{H}}} = \frac{1}{2\times 0{\cdot}000105},$$

therefore $$k_2 = 1{\cdot}83\times 10^{-4}.$$

Combining this with the value 10^{-9} found for k_1k_2 for a current of 6 amperes, we have a value

$$k_1 = 5{\cdot}5\times 10^{-6} = 550 \text{ cm. per second per volt per centimetre.}$$

This is about one-thirtieth of the velocity of the negative corpuscle, and since from the above deduction of this velocity it is evident that k is proportional to $\sqrt{\frac{1}{m}}$, the mass of the positive ions must be about 900 times that of a corpuscle, or about the same as that of a hydrogen atom. The positive ions then cannot be either copper or air molecules, but may be the same as the carriers of positive electricity detected by Prof. J. J. Thomson in the Kanalstrahlen. On this view, however, it is rather difficult to give a satisfactory explanation of the way in which k_1k_2 increases with the current. For k_1k_2 is only directly proportional to the temperature, and the experiments show that k_1k_2 is trebled by a rise in the current from 2 to 9 amperes. This would indicate a rise in temperature from 1000° to 3000°, which is larger than is probable. If the positive ions were groups of copper or air molecules the rise could be explained as due to a rise in temperature accompanied by dissociation of these groups.

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[*] Langevin, Theses, Paris, 1902, p. 47.

[†] Townsend, 'Phil. Mag.,' 1901, p. 198.

In this connection it may be mentioned that the negative electrode was always much more oxidised and corroded than the positive, but this may have been due to its being the lower electrode, and thus meeting the upward convection air current and robbing it of its oxygen before it reached the positive electrode.

Conclusions.—The speed of the electric arc across a transverse magnetic field has been measured and found to be sensibly

(1) independent of the arc length,
(2) proportional to the magnetic field strength, and
(3) to increase linearly with the current.

From the experiments the value k_1k_2, the product of the speeds of the ions carrying the current, has been calculated. From this value, by assuming the negative ion to be a corpuscle and calculating its velocity, it has been shown that the carriers of positive electricity have a mass of the same order as that of the hydrogen atom.

In conclusion, I wish to thank Prof. H. A. Wilson for suggesting to me the subject of this research and for much kind advice and encouragement during its progress.